What is claimed is:

1. A spark plug comprising:

a cylindrical metallic housing;

a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

a center electrode tip fixed to said one end of said center electrode and extending in the same direction as an axis of said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode; and

a columnar ground electrode tip fixed to an end surface of said distal portion of the ground electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground electrode where the ground electrode is fixed to said metallic housing;

said ground electrode tip extends along an axis crossing with the axis of the distal portion of the ground electrode, so that said ground electrode tip protrudes from the end surface of the distal portion of said ground electrode and extends toward said center electrode; and

an axis of said center electrode tip is in a cross or skew relationship with an axis of said ground electrode tip.

2. The spark plug in accordance with claim 1, wherein a crossing angle between said axis of said center electrode tip and said axis of said ground electrode tip is in an angular range from 5° to 70°.

3. The spark plug in accordance with claim 1, wherein said ground electrode tip protrudes toward said center electrode by a protruding length in a range from 0.3 mm to 1.5 mm with respect to the side surface of said distal portion of said ground electrode.

4. The spark plug in accordance with claim 1, wherein

an X axis represents said apical surface of said center electrode tip and a Y axis represents the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin (0, 0) of said coordinate plane,

a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents a discharge gap, and

an axial deviation amount between the axis of said center electrode tip and the axis of said ground electrode tip is within $\pm d/2$ in a direction normal to said coordinate plane, and a swing amount of said closest point 'A' is within $\pm d/2$ mm in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.

5. A spark plug comprising:
a cylindrical metallic housing;
a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;
a center electrode tip fixed to said one end of said center electrode and extending in the same direction as an axis of said center electrode;
a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode so that an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode; and

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a columnar ground electrode tip fixed to an end surface of said distal portion of the ground electrode or fixed to a side surface of said distal portion of the ground electrode facing to said center electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein said ground electrode tip extends along an axis crossing with the axis of the distal portion of the ground electrode, so that said ground electrode tip protrudes from the end surface of the distal portion of said ground electrode and extends toward said center electrode;

a crossing angle between an axis of the center electrode tip and an axis of the ground electrode tip is in an angular range from 5° to 70°; and

a fixing portion of said ground electrode tip to said ground electrode is far from said metallic housing in an axial direction of said center electrode compared with the apical surface of said center electrode tip.

6. The spark plug in accordance with claim 5, wherein said ground electrode tip protrudes toward said center electrode by a protruding length in a range from 0.3 mm to 1.5 mm with respect to the side surface of said distal portion of said ground electrode.

7. The spark plug in accordance with claim 5, wherein

an X axis represents said apical surface of said center electrode tip and a Y axis represents the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin (0, 0) of said coordinate plane,

a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents a discharge gap, and

an axial deviation amount between the axis of said center electrode tip and

the axis of said ground electrode tip is within ± d/2 in a direction normal to said coordinate plane, and a swing amount of said closest point 'A' is within ± d/2 mm in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.

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8. A spark plug comprising:

a cylindrical metallic housing;

a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

10   a center electrode tip fixed to said one end of said center electrode and extending in the same direction as an axis of said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode; and

15   a columnar ground electrode tip fixed to a side surface of said distal portion of the ground electrode facing to the center electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground

20 electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground electrode where the ground electrode is fixed to said metallic housing; and

an axis of said center electrode tip is in a cross or skew relationship with

25 an axis of said ground electrode tip.

9. The spark plug in accordance with claim 8, wherein a crossing angle between said axis of said center electrode tip and said axis of said ground electrode tip is in an angular range from 5° to 70°.

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10. The spark plug in accordance with claim 8, wherein said ground

electrode tip protrudes toward said center electrode by a protruding length in a range from 0.3 mm to 1.5 mm with respect to the side surface of said distal portion of said ground electrode.

5   11. The spark plug in accordance with claim 8, wherein

an X axis represents said apical surface of said center electrode tip and a Y axis represents the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin

10   (0, 0) of said coordinate plane,

a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents a discharge gap, and

15   an axial deviation amount between the axis of said center electrode tip and the axis of said ground electrode tip is within $\pm d/2$ in a direction normal to said coordinate plane, and a swing amount of said closest point 'A' is within $\pm d/2$ mm in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.

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12. A spark plug comprising:

a cylindrical metallic housing;

a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

25   a center electrode tip fixed to said one end of said center electrode and extending outward from said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode; and

30   a columnar ground electrode tip fixed to an end surface of said distal portion of the ground electrode, with an apical surface of said ground electrode

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tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground electrode where the ground electrode is fixed to said metallic housing;

said ground electrode tip extends along an axis crossing with the axis of the distal portion of the ground electrode, so that said ground electrode tip protrudes from the end surface of said distal portion of said ground electrode and extends toward said center electrode; and

the axis of said center electrode is in a cross or skew relationship with an axis of said ground electrode tip.

13. The spark plug in accordance with claim 12, wherein a crossing angle between said axis of said center electrode and said axis of said ground electrode tip is in an angular range from 5° to 70°.

14. The spark plug in accordance with claim 12, wherein said ground electrode tip protrudes toward said center electrode by a protruding length in a range from 0.3 mm to 1.5 mm with respect to the side surface of said distal portion of said ground electrode.

15. A spark plug comprising:
a cylindrical metallic housing;
a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;
a center electrode tip fixed to said one end of said center electrode and extending outward from said center electrode;
a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said

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center electrode; and

a columnar ground electrode tip fixed to a side surface of said distal portion of the ground electrode facing to said center electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center

5 electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground

10 electrode where the ground electrode is fixed to said metallic housing; and

the axis of said center electrode is in a cross or skew relationship with an axis of said ground electrode tip.

16. The spark plug in accordance with claim 15, wherein a crossing angle

15 between said axis of said center electrode and said axis of said ground electrode tip is in an angular range from 5° to 70°.

17. The spark plug in accordance with claim 15, wherein said ground electrode tip protrudes toward said center electrode by a protruding length in a

20 range from 0.3 mm to 1.5 mm with respect to the side surface of said distal portion of said ground electrode.

18. The spark plug in accordance with any one of claims 1 to 17, wherein said center electrode tip has a cylindrical shape with a cross section in a range

25 from 0.07 mm^2 to 0.79 mm^2 and said ground electrode tip has a cylindrical shape with a cross section in a range from 0.07 mm^2 to 1.13 mm^2.

19. The spark plug in accordance with any one of claims 1 to 17, wherein said ground electrode has a tapered shape with a cross-sectional area gradually

30 narrowing with decreasing distance from said end surface.

20. The spark plug in accordance with any one of claims 1 to 17, wherein said ground electrode has an outer layer made of a Ni alloy and an inner layer made of a copper or copper alloy.

21. The spark plug in accordance with any one of claims 1 to 17, wherein said center electrode tip and said ground electrode tip are made of a Pt alloy including at least one additive selected from the group consisting of Ir, Ni, Rh, W, Pd, Ru and Os.

22. The spark plug in accordance with claim 21, wherein a material for said center electrode tip and said ground electrode tip is a Pt alloy containing at least one additive selected from the group consisting of Ir (50 weight% or less), Ni (40 weight % or less), Rh (50 weight% or less), W (30 weight% or less), Pd (40 weight% or less), Ru (30 weight% or less), and Os (20 weight% or less).

23. The spark plug in accordance with any one of claims 1 to 17, wherein said center electrode tip and said ground electrode tip are made of a Ir alloy including at least one additive selected from the group consisting of Rh, Pt, Ni, W, Pd, Ru and Os.

24. The spark plug in accordance with claim 23, wherein a material for said center electrode tip and said ground electrode tip is a Ir alloy containing at least one additive selected from the group consisting of Rh (50 weight% or less), Pt (50 weight % or less), Ni (40 weight% or less), W (30 weight% or less), Pd (40 weight% or less), Ru (30 weight% or less), and Os (20 weight% or less).

25. A method for manufacturing a spark plug,
said spark plug comprising:
a cylindrical metallic housing;
a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

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a center electrode tip fixed to said one end of said center electrode and extending in the same direction as an axis of said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode; and

a columnar ground electrode tip fixed to an end surface of said distal portion of the ground electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground electrode where the ground electrode is fixed to said metallic housing;

said ground electrode tip extends along an axis crossing with the axis of the distal portion of the ground electrode, so that said ground electrode tip protrudes from the end surface of the distal portion of said ground electrode and extends toward said center electrode; and

an axis of said center electrode tip is in a cross or skew relationship with an axis of said ground electrode tip,

said manufacturing method comprising the steps of:

assuming an X axis representing said apical surface of said center electrode tip and a Y axis representing the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin (0, 0) of said coordinate plane, and

arranging said center electrode tip and said ground electrode tip so as to satisfy a positional relationship that a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents

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a discharge gap,

wherein the positional relationship between said center electrode tip and said ground electrode tip is determined with a tolerance that an axial deviation amount between the axis of said center electrode tip and the axis of said ground

5   electrode tip is within $\pm d/2$ in a direction normal to said coordinate plane and a swing amount of said closest point 'A' is within $\pm d/2$ in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.

26. A method for manufacturing a spark plug,

10   said spark plug comprising:

a cylindrical metallic housing;

a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

a center electrode tip fixed to said one end of said center electrode and

15   extending in the same direction as an axis of said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode so that an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode; and

20   a columnar ground electrode tip fixed to an end surface of said distal portion of the ground electrode or fixed to a side surface of said distal portion of the ground electrode facing to said center electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

25   wherein said ground electrode tip extends along an axis crossing with the axis of the distal portion of the ground electrode, so that said ground electrode tip protrudes from the end surface of the distal portion of said ground electrode and extends toward said center electrode;

a crossing angle between an axis of the center electrode tip and an axis of

30   the ground electrode tip is in an angular range from 5° to 70°; and

a fixing portion of said ground electrode tip to said ground electrode is far

from said metallic housing in an axial direction of said center electrode compared with the apical surface of said center electrode tip,

said manufacturing method comprising the steps of:

assuming an X axis representing said apical surface of said center electrode tip and a Y axis representing the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin (0, 0) of said coordinate plane, and

arranging said center electrode tip and said ground electrode tip so as to satisfy a positional relationship that a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents a discharge gap,

wherein the positional relationship between said center electrode tip and said ground electrode tip is determined with a tolerance that an axial deviation amount between the axis of said center electrode tip and the axis of said ground electrode tip is within $\pm d/2$ in a direction normal to said coordinate plane and a swing amount of said closest point 'A' is within $\pm d/2$ in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.

27. A method for manufacturing a spark plug,

said spark plug comprising:

a cylindrical metallic housing;

a center electrode accommodated in said metallic housing, with one end protruding and extending from one end of said metallic housing;

a center electrode tip fixed to said one end of said center electrode and extending in the same direction as an axis of said center electrode;

a ground electrode having a proximal portion fixed to said one end of the metallic housing and a distal portion extending toward said one end of said center electrode; and

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a columnar ground electrode tip fixed to a side surface of said distal portion of the ground electrode facing to the center electrode, with an apical surface of said ground electrode tip opposed to an apical surface of said center electrode tip via a discharge gap,

wherein an acute angle is formed between an axis of said distal portion of the ground electrode and said axis of said center electrode when said ground electrode is projected on a virtual plane including said axis of the center electrode and a cross-sectional centroid of a proximal end of said ground electrode where the ground electrode is fixed to said metallic housing; and

an axis of said center electrode tip is in a cross or skew relationship with an axis of said ground electrode tip,

said manufacturing method comprising the steps of:

assuming an X axis representing said apical surface of said center electrode tip and a Y axis representing the axis of said center electrode tip in a coordinate plane including both of the axis of said center electrode tip and the axis of said ground electrode tip, with a crossing point of said X axis and said Y axis being an origin (0, 0) of said coordinate plane, and

arranging said center electrode tip and said ground electrode tip so as to satisfy a positional relationship that a point 'A' of said ground electrode tip closest to said center electrode tip is expressed by a coordinate value $(-b/2, \chi)$ when a point 'B' on the apical surface of said center electrode tip closest to said ground electrode is expressed by a coordinate value $(-b, 0)$, where χ represents a discharge gap,

wherein the positional relationship between said center electrode tip and said ground electrode tip is determined with a tolerance that an axial deviation amount between the axis of said center electrode tip and the axis of said ground electrode tip is within $\pm d/2$ in a direction normal to said coordinate plane and a swing amount of said closest point 'A' is within $\pm d/2$ in a direction parallel to said X axis, where 'd' represents a diameter of said ground electrode tip.